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XXVII.—*On the Structure called Eozoon canadense in the Laurentian Limestone of Canada.* By H. J. CARTER, F.R.S. &c. (*A letter to Professor W. KING, Sc.D., Galway.*)

MY DEAR SIR,—On the 13th instant I had the pleasure to send you a “Card” acknowledging the safe arrival of your letter of the 10th inst. and specimen of Laurentian Limestone containing the so-called *Eozoon canadense*, intimating at the same time that after a few days I would answer you more at length. I now proceed to do so.

With the copy of your Papers\* on the mineral origin of this formation (received on the 9th August last) and your present letter under reply, together with the decalcified slice of Laurentian Limestone (about  $2 \times 2 \times \frac{2}{8}$  inch in size), which you state to be from Canada and to have been forwarded to your colleague Professor Rowney by Dr. Carpenter as a “typical specimen of *Eozoon canadense*,” I also possess in my own cabinet perhaps some of the most perfectly fossilized foraminiferous structure in existence; so that, for the purpose of comparing the two, I could not be more satisfactorily provided.

That I should feel interested in the question at issue as to the identity of the Laurentian Limestone with that of foraminiferous structure may be easily conceived by the accom-

\* ‘Proceedings of the Royal Irish Academy,’ vol. x. pp. 506–551, and 2nd series, vol. i. 1871.

panying copy of my paper on the "Form and Structure of *Operculina arabica*," read before the Bombay Branch of the Royal Asiatic Society so far back as May 1852, and published in their Journal and in the 'Annals and Magazine of Natural History' of the following year, together with many other papers subsequently published in the latter, from time to time, on the structure and adult forms of several fossilized Foraminifera, including new species. You may also thus fully understand how grateful I feel to you for having been the first to send me a specimen of the Laurentian rock, and to bring the subject of its structure and composition before me under the mineralogical point of view detailed in the papers published conjointly by yourself and Prof. Rowney, to which I have alluded.

You will also observe, by the figures in the plate attached to my paper on *Operculina*, that, at a very early period, I demonstrated the system of foraminiferous structure in a recent *Operculina* and identified it with the structure of a fossil Nummulite. How much more completely than others, a comparison of our descriptions and illustrations respectively will show, it not being my business here to lay claim to any thing beyond a position to be able to compare genuine foraminiferous structure, both living and fossilized, with the so-called *Eozoon canadense*.

Previously, however, to stating my observations in this respect, I would say a word or two on the law of form in organized beings; for this bears upon the subject.

That the "law" exists in the mineralogical as well as in the organic kingdom may be seen in the common mineral growth termed "dendrites." But, besides this familiar example, it may be observed in what are called "moss-agates," coming from the geodes of trap—that is, from a volcanic rock. Of the latter I possess a polished and mounted specimen, composed of opalescent chalcedony, in which there is a growth of *glauconite* that, when viewed under an inch compound power, would, by any one not acquainted with the geological facts, be termed a "branched Conferva."

Again, I possess a similarly polished and mounted specimen of green calcspar (that designated by Prof. Haughton "Hislopite"), also from a trappean geode of Western India, in which there is a growth of *glauconite* so like the remains of dead incrustated Conferva from a dirty pond that, without being acquainted with its geological position, this would also be pronounced to be Conferva in such a state fossilized.

So far the "law of form" is the same in both kingdoms, and hence the necessity of knowing this before we state confi-

dently that such and such forms are or are not organic. The mistake of identifying dendrites &c. with fossilized plants has often occurred, but not with acknowledged competent authorities.

Lastly, I possess a similar specimen of green *Heulandite* from the trap of Western India, in which the green colour is owing to the presence of a *granular* growth of *glauconite* among the translucent zeolithic mineral; and this brings me to the so-called *Eozoon canadense*, which you and your colleague Prof. Rowney conclude to be of a like nature, viz. granular serpentine in calcspar.

With your mineralogical view I have nothing to do, as it would be presumption in me to even praise such high authorities; but, from the fossilization point of view, I may be permitted to state facts which I feel able to appreciate in connexion with the subject.

Before, however, going to adult foraminiferous structure for comparison, it is desirable to premise its primary, which is its elementary, form.

Thus the assumed ovum of a foraminiferous animal is soft, spherical, filled with granuliferous sarcode, and nucleated while in the chambers of the adult living animal. After this, on approaching the embryonal state, the capsule becomes calcareous and pierced all round with minute apertures, save at one point, where there is a large one, from which issues, in the living and active condition, the internal sarcode in the form of a short cord terminated by a reticulated lash of filaments (pseudopodia) of different lengths, which are ever changing in shape (*Amæba*-like) as they are put forth in search of food &c. The calcareous covering then becomes thickened, and the "apertures" elongated into tubes which, in juxtaposition, descend perpendicularly through the crust thus formed, and keep up a connexion between the exterior and interior of the embryo.

This is the elementary form or first chamber of a foraminiferous animal; and a repetition of it, produced by the sarcode which issues from the large aperture, thus goes on stoloniferously producing chamber after chamber, of the shape peculiar to the individual, until the increments thus produced at last arrive at the ultimate form of the species.

The soft ovum can only be seen in the recent animal; but the spherical embryos, both in my specimens of recent *Operculina arabica* and in the fossilized Nummulites &c., may be seen in abundance, not only in the chambers, but in the tubes (that is, in the branches of the stoloniferous prolongations of sarcode; for they also clothe themselves with a calcareous layer), on their way out from the chambers to the exterior.

In a specimen of *Orbitolites* which I possess the *embryos* (2 to 10 or more in most of the chambers) appear to be elliptical, almost like a *Miliola*!

Thus, as stated, the foraminiferous animal, built cell over cell, at length arrives at the specific form, whether Nummulite or Orbitoides &c., and throughout is but a repetition of the embryonal chamber modified only in shape to accord with the species. But still there are the tubuli perpendicular to the plane of growth in the crusts of the chambers respectively; there are the chambers; and in the intervals of the general structure, which are filled up with calcareous material and thus form the skeleton, is a reticulated system of canals produced by the branches of the stoloniferous sarcode, communicating in all directions with the chambers through their walls and with one another, finally opening on the exterior of the test, and in their course, as I have before stated, often presenting the spherical embryos in their transit from the chambers to the exterior; while the tubuli of the crust of the chambers, being developed with these crusts successively as they are piled upon one another, form thus a *continuous* communication, through the cavities of the chambers, between the *exterior* and *very centre* of the test.

Hence, if a section of a fossilized form be made just above or just below the chamber (that is, *outside* it), the tubuli of the upper or lower part of the crust *must be seen*; while if it be made through the chamber, then the plane of the openings inside *must be seen*. Indeed it is impossible to make a section in which they do not come into view, or to examine a piece not larger than a small pin's head without seeing them; so that to pretend to identify the acicular structure sometimes observed to be standing perpendicularly on, but much more frequently *parallel* with, the surface of the grains of serpentine in the Laurentian Limestone (which grains have been viewed as the *casts* of the chambers of a foraminiferous animal) with these tubuli, that always run *directly* to the chamber, and should be thus seen in almost every atom of foraminiferous structure, seems to me to be nonsense\*.

Nothing can be clearer than all that I have above stated of foraminiferous structure, as seen under an inch-focus compound power in my infiltrated specimens of *Nummulites*, *Orbitoides*, &c. from the Eocene formation of Western India.

But in vain do we seek in the so-called *Eozoon canadense* for the unvarying perpendicular tubuli, the *sine quâ non* of

\* For good figures of this acicular structure, see Prof. King and Rowney's paper, read 12th July, 1869, Transactions of Royal Irish Academy, vol. x. p. 506, pls. i. to iv. figs. 1 to 6 & 10a &c respectively.

foraminiferous structure. In vain do we look for that regularity of chamber-formation which, in the amorphous growth assigned to the so-called *Eozoon*, might be equally well assumed to be identical with the heterogeneous mass of chambers on each side of the central plane of *Orbitoides dispansa*, accompanied by the transverse bars of stoloniferous structure uniting one chamber to the other. In short, in vain do we look for the casts of true foraminiferous chambers at all in the grains of serpentine; they, for the most part, are not subglobular, but subprismatic.

With such deficiencies I am at a loss to conceive how the so-called *Eozoon canadense* can be identified with foraminiferous structure, except by the wildest conjecture; and then such identification no longer becomes of any scientific value.

Having examined the slice of Laurentian Limestone which you have so courteously submitted to me in thick and thin polished sections mounted in Canada balsam, by transmitted and also by reflected light, also the surface of the "decalcified" slice as it came from you, in all directions with  $\frac{1}{4}$ - and 1-inch focus compound powers respectively, I must unhesitatingly declare that it presents no foraminiferous structure anywhere. Nor does its structure bear so much resemblance to that of a foraminiferous test as the legs of a table to those of a quadruped; while if such be the grounds on which geological inferences are established, the sooner they are abandoned the better for geology, the worse for sensationalism!

The contents of this letter are open to no controversy. My knowledge of foraminiferous structure has been obtained step by step, beginning with the recent and then going to the fossilized forms, making and mounting my own sections, from which afterwards my illustrations and descriptions have been taken. If others who have pursued a similar course of instruction differ from me in what I have above stated, the question can only be decided by a third party, not on verbal arguments alone, but on a comparison of the actual specimens, as prolonged disputation, in matters of opinion, soon disgusts every body but the combatants, and can end in nothing but a fearful waste of time that might be better employed. The accompanying slide I must ask you kindly to return at your convenience, as, you will admit, such specimens of foraminiferous structure are not so plentiful as Laurentian Limestone!

I am, dear Sir,

Yours very truly,

H. J. CARTER.

"The Cottage,"  
Budleigh-Salterton, Devon,  
29th December 1873.